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USE OF GAS TURBINE PLANTS FOR ELECTRIC POWER PRODUCTION IN LESS-DEVELOPED COUNTRIES

By The Energy Division of the Economic Commission for Europe

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USE OF GAS TURBINE PLANTS FOR ELECTRIC POWER PRODUCTION IN LESS-DEVELOPED COUNTRIES

by

The Energy Division of the Economic Commission for Europe

I. General description

1. Gas turbines are a comparatively new type of prime mover but are already in wide use for many different applications. At present gas turbines are being used in many fields of industry and transport: aviation, power plants, locomotives, ocean-going vessels, lorries and cars, metallurgical, chemical and other industries, oil and gas pumping stations and so on. Besides aviation, and special gas turbines with a short-service life (500-1000 hours) all others have a long-service life (10,000-100,000 hours). In some gas turbines with a long-service life more wearing parts (i.e. first stage blades, burners, etc.) are being renewed after 15,000-20,000 working hours.

2. Long-life gas turbines, including those used in power stations, are being produced in Canada, Czechoslovakian Socialist Republic, France, Italy, Japan, the Federal Republic of Germany, Sweden, Switzerland, the United Kingdom, the USSR, and other countries. The unit capacity of the gas turbines ranges from several kW up to 50 MW. The most powerful gas turbines in use at the present time are the 40 MW set installed in the Vastervic power station in Sweden, produced by the Swedish concern STAL, and the 50 MW unit installed in the Kharkov power station in the USSR, produced by Kharkov Turbine Works.

3. There are three types of gas turbine plants: open-cycle; closed-cycle, and those with free piston generator of working median.

In open-cycle gas turbines the working median enters as air and passes through a compressor, a combustion chamber, a turbine and discharges to the atmosphere. In the closed-cycle gas turbine clear air is used as a working median, which is circulated through a closed system. In gas turbine plants with free piston generators the working median is prepared in the free piston cylinders on the diesel principle but expands in the gas turbine.

4. Open-cycle gas turbines are the most developed and widely used. There are: single-shaft gas turbines which are cheap, simple and less economical, and 2-shaft plants with intercooler, regenerator and reheating working gases which are more complicated. The latter are more expensive but more economical.

Pressure of working median in single-shaft open-cycle gas turbines varies from 3 to 6 atm, and in 2—shaft plants from 10 to 20 atm. The initial tem-

perature of working median in single-shaft open-cycle gas turbine varies from 650 C to 800 C. Efficiency of single-shaft open-cycle gas turbines ranges from 15-20 per cent without regenerator, and from 20-25 per cent with regenerator. For 2-shaft arrangements with inter-color, regenerator and reheating working gases, the efficiency rises and is in the range of from 26 - 32 per cent.

5. Closed-cycle gas turbine plants are comparatively more complicated than open- cycle units. The pressure here is usually 40-60 atm. and back pressure 4-6 atm. The initial temperature of the working median is about 700°C. Efficiency of closed-- cycle gas turbine plants is at a level of 30-32 per cent. Capital investment in such plants is, however, higher than in corresponding open-cycle plants.

6. In gas turbine plants with free piston generators the working median before entering the gas turbine has a comparatively low pressure and temperature is at 4-6 atm. and 420-450°C. It is possible before entering gases to turbine to heat them in the combustion chamber up to 650°C and higher. The efficiency of free piston gas turbine plants is fairly high - 32-34 per cent, but their unit capacity is limited. In existing power plants the largest unit of this type has a capacity of 6 MW.

7. Gas turbine plants for power can use different kinds of fuel: liquid fuel (distilled fuel and heavy bunker oil), natural gas, casing head gases, blast furnace gas and additionally, closed-cycle gas turbine plants can use pulverized coal. The use of natural gas and distilled liquid fuel does not cause any difficulties in the operation of the plant. The use of heavy bunker oils causes some obstacles in servicing, the worst being the deposits of sodium and calcium salts on the turbine blades. A second problem occurs when the heavy fuel contains vanadium, which causes so-called vanadium corrosion of turbine blades at temperatures higher than 650°C. To eliminate these difficulties, the heavy fuel can be specially treated before being used in the gas turbines. A mixture of distilled and heavy oil can be also used in gas turbine plants.

II. Experiences and tendencies in the use of Gas Turbines.

8. At the present time there is a wide experience in the use of gas turbine plants for the production of electricity and also for other purposes. Tables 1 and 2 give some data for selected gas turbine plants used for the production of electric power including their main characteristics. In service gas turbines work to their fullability and have a wide manoevering power.

9. For the past few years there has been a visible tendency in the use of gas turbines for the covering of peak loads. At the same time there is also the tendency to introduce fully automatic plants on which the starting, running and shutting-down is done automatically. This also means that the plant can be operated by remote control without an operator on the site. The plant can be put into operation in a very short time - for some plants it takes 2 minutes only including the taking of load.

10. The second tendence in the use of gas turbines for power is combining production of electricity and heat for heating and other purposes. In this case the efficiency of the plant increases up to 70 per cent.

11. The third tendence in the use of gas turbine plants for power is the use of them combined with steam power plants in so-called steam-gas cycle. This combined cycle increases the efficiency of the plant as a whole by 4 - 8 per cent which brings the efficiency of the combined gas-steam plant up to 40 per cent and higher.

Besides the above three points gas turbine plants are being used as mobile electric power plants, as explained in Section III.

III. Mobile gas turbine plants.

12. Besides stationary gas turbine plants, there are in use, in several cases, mobile gas turbine plants. The use of these mobile gas turbine plants has increased somewhat during the last few years. The mobile plants are mounted on railway trucks or on the chassis of lorries, and sometimes, on special skis when they can be moved by tractor or other transport facilities in the areas where there are no railway, highway or road.

13. Mobile gas turbine plants can be very useful to countries just beginning to develop industrially. In these countries, as a rule, there are not many facilities for deliveries/electricity to isolated areas where industrial plants are being built. When, however, these industrial sites are completed and they have created their own source of electricity the mobile plant can be moved to other isolated areas just starting to develop.

14. At present mobile gas turbine plants are being produced by many turbo producing firms :

Brown Boveri	Capacity of	6.500 kW and 14,500 kW
Bristol Siddley	" "	3,000 kW
Fiat	" "	6,400 kW
General Electric	" "	11,000 kW
Ruston Hornsby	" "	300 and 930 kW
Blackburn Houchin	" "	200 kW
Clark Bros.	" "	5,000 kW

Mobile gas turbine plants are being produced also in the Czechoslovakian Socialist Republic, Soviet Union and different firms in other countries.

IV. Choice of gas turbine plants

15. Before finally choosing gas turbine plants for power one must carefully study both technically and economically all the possibilities and advantages offered by the different types of plants.

16. For the purpose of covering peak loads at a nominal capacity of 10-15 MW and with a considerably short running time (up to 500 hrs. per year), one should choose the most simplest type of plant, i.e. 1-shaft unit without intercooler, regenerator and reheat combustion chamber. If available, natural gas would be the best type of fuel for all types of gas turbine plants used for power. In the above case, if no natural gas is available distilled liquid fuel should be used. As the cost component for fuel for this kind of installation is comparatively small the difference in price between distilled and heavy liquid fuel does not cover all obstacles caused by using heavy fuel. A more complicated, but more economical, plant can be chosen for the covering of peak loads, working up to 3,000 hours per year, i.e. 2-shaft, with intercooler, reheater, and in some cases regenerator. After natural gas one can use heavy fuel oil, bearing in mind that in this case, the fuel component in the cost of electricity is higher and it would be more economical and reasonable to use a cheaper fuel. Gas turbine plants with free piston generators also can be used successfully for the above purposes.

17. For basic load purposes when the plant works 3,000 - 6,000 hours per year it should be chosen a more complete open-cycle or closed-cycle gas turbine plant. Plants with free-piston generator can also be used. In some cases, gases after free piston generator and before entering turbine can be additionally heated in the combustion chamber. Heavy fuel can be used as a fuel if gas is not available.

When choosing gas turbine plants it would be useful to have a consultation with an unprejudiced expert or organisation.

V. Cost of gas turbine plants for power.

18. There is a wide range in the cost of gas turbine plants per installed kW. This depends on many factors, the main ones being as follows:

(1) Application and life span.

19. It is necessary to distinguish between the two types of plant:

a) - for peak load purposes with a short running time per year (up to 500 hours) with a considerably short life span - 10,000-20,000 hours.

b) - plants for basic load purposes with working time over to 3,000 hours per year and with a life span of up to 100,000 hours.

The first, as was mentioned before, are of simple construction and with a considerably low efficiency (18-25 per cent) and considerably cheaper. The second are more complicated with reheater, regenerator, 2 or 3 stages of compression, 2 stages of expansion, and so on. These are more economical (efficiency over 30 percent), and consequently more expensive. Gas turbine plants for the combined production of electricity and heat are more complicated than for the production of electricity only, and consequently, are more expensive but more economical. They have an efficiency of up to 70 per cent.

(2) Fuel used.

20. The values of auxiliaries in connexion with the preparation and burning of fuel depends on the type of fuel chosen. Very few preliminary equipment is needed where natural gas is used as a fuel when it is being delivered to the gas turbine plant at a pressure higher than in the combustion chamber. Where distillate liquid fuel is used, it needs more preliminary equipment than for gas, but less than for heavy fuel. When heavy fuel is used (bunker oil) it is sometimes necessary to make some preliminary preparation to free it from vanadium or from sodium and calcium salts. Besides this it is sometimes also necessary to have preliminary equipment connected with the cleaning and washing of the turbine blades and heat exchanger surfaces from deposits from the different mineral salts and hard products of the combustion. The type of fuel chosen for burning in the combustion chamber of the gas turbine plant influences the cost of installed capacity including the cost of preliminary equipment connected with the preparation for burning fuel and cleaning and washing of deposits.

(3) Unit capacity

21. If the same type of equipment to the gas turbine plants is being installed the cost of installed kW depends on the unit capacity. As a rule, the cost of kW decreases with increasing unit capacity.

22. Besides the above three main factors influencing the cost of the plants, there are many other factors, for instance, the type of plant, market conjuncture of power equipment, and so on.

23. Costs of gas turbine plants based on facts are given herewith according to data given in periodic technical literature.

COSTS OF GAS TURBINE PLANTS BASED ON FACTS AVAILABLE

	Name of stations	Produced by :	Capacity (kW)	Purpose of the plant	Cost $/kW	Commissionning date
1	Alterbacken (Sweden)	Brown Boveri	1 x 25000	Seasonal work	83	1958
2	Manami (Bahrain)	"	2 x 6000	"	139	1958
3	Egmond (Canada)	"	2 x 25000	Seasonal work	172	1957
4	Santa Rosa (Peru)	"	1 x 1000	Peak load	113	1949
5	El Convento (Venezuela)	"	2 x 20000	"	140	1958
6	Ferrybridge (United Kingdom)	Bristol Siddeley	4 x 17500	"	68.3*	Placed order in 1962
7	West Burton (United Kingdom)	English Electric	4 x 17500	" and reserve	68.3*	Placed order in 1962
8	Rio Pecos (U.S.A.)	"	1 x 5000	Basic load	159	. .
9	Caracas (Venezuela)	General Electric	1 x 21500	"	139	1959
10	Pennsylvania (U.S.A.)	"	1 x 22000	Peak load	100	1962
11	Orlando (U.S.A.)	"	1 x 16500	"	110	. .
12	South Carolina (U.S.A.)	"	4 x 11000	"	100	1961
13	Delaware Power Co. (U.S.A.)	"	1 x 11700	"	101.9	1962
	"	Pratt Witney	1 x 12900	"	101.9	1962
14	Georgia (Canada)	General Electric of Canada	2 x 19750	Basic Load	134	1955
			2 x 18000	"	166	1955

* without cost of building

Data given above on the cost of gas turbine plants per kW installed are far from being complete. Nevertheless, they give some idea about this important question. After gas turbines have reached perfection and the unit capacity increased and become more specialized, so the price per kW installed decreases.

TABLE 1

Characteristics of Gas Turbine Plants used in the Production of Electric Power in Europe and elsewhere

NO.	Country	Plant Location	Manufacturer	Type of plant (a)	Year of initial operation	Unit capacity (MW) and number of units	Fuel used	Principal Characteristics							Characteristics of Main Equipment								
															Turbine			Compressor			Generator		
								Thermal cycle (b)	Initial temperature (°C)	Compression ratio	Number of intercoolers	Regeneration effectiveness (%)	Number of heat stages	Thermal efficiency (%)	Number of cylinders	r.p.m.	Inner efficiency (%)	Number of cylinders	r.p.m.	Adiabatic efficiency (%)	Capacity (kVA)	Voltage (kV)	r.p.m.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	AUSTRIA	Donawitz	Brown Boveri	B	1958	1 x 4	Blast Furnace gas	0	750		0	75	1	28.0	1	..	..	1	..	..	..	..	..
2		Neusiedl	Brown Boveri	B	1958	1x13.9	Natural gas	0	620	6	0	0	1	21.7	1	..	..	1	..	..	..	..	..
3		Korneuburg	Brown Boveri	B	1959/60	2x25	Natural gas	0	650	20	1	0	2	26.0	2	..	..	2	..	..	35,000	6.3	3,000
4		Schwechat	Brown Boveri	B	1961	1x6.5	Natural gas) Diesel oil)	0	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
5	UNITED KINGDOM	Princetown	Bristol Siddeley	P	1959	1 x 3	Diesel oil	0	852	7.3	0	0	1	22.0	1	4,250	..	1	4,250	..	3,200	11	1,000
6		Lynton	Bristol Siddeley	P	1960	1 x 3	" "	0	852	7.3	0	0	1	22.0	1	4,250	..	1	4,250	..	3,200	11	1,000
7		Porlock	Bristol Siddeley	P	1961	1 x 3	" "	0	852	7.3	0	0	1	22.0	1	4,250	..	1	4,250	..	3,200	11	1,000
8		Hams Hall	Bristol Siddeley	P	on order	1x15	" "	0	837	..	0	0	1	24.0	1	3,000	..	1	6,300	..	25,000	11	3,000
9		Ferrybridge	Bristol Siddeley	P	on order	3x17.5	" "	0	..	..	0	0	1	..	1	..	..	1	..	..	..	..	..
10		West Barton	English Electric Rolls Royce	P	on order	3x17.5	" "	0	..	..	0	0	1	..	1	..	..	2	..	..	..	..	..
11	FRANCE	Cherbourg	SIGMA	P	1955	1 x 6	Liquid fuel	FP	450	4.1	0	0	1	35.0	1	..	..	8	..	..	10,000	5.5	..
12		Tours	SIGMA	P	1958	1 x 6	" "	FP	650	5.2	0	0	2	25.7	1	7,500	..	6	..	..	10,000	5.5	3,000
13		St. Dizier	Brown Boveri	P	1956	1 x 6	" "	0	750	4.6	0	0	1	20.3	1	..	..	1	..	..	10,000	..	..
14		Angers	Rateau		1958	1 x 6	" "	0	670	4.1	0	0	1	17.0	1	..	..	1	..	..	10,000	..	..
15		Garchisy	S.F.A.C.		1960	1 x 6	" "	0	700	4.5	0	0	1	17.0	1	..	..	1	..	..	10,000	10.5	..
16	ITALY	Livorno	Brown Boveri	BP	1956	2x25		0	650	16	1	0	0	24.0	2	4,750	..	2	4,750	..	32,000	..	3,000
17		Rome	Brown Boveri	BP	1957	1x25		0	650	16	1	0	0	24.0	2	4,750	..	2	4,750	..	32,000	10	3,000
18		Turin	Brown Boveri	BP	1957	1 x 6		0	730	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
19		Chivasso (Turin)	Fiat		1961	1x32	Gas, liquid fuel	0	730	16.5	1	0	2	27.1	..	5,740/ 3,000	..	2	5,740/ 3,000	..	..	..	3,000

TABLE I (continued)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
20	Rumania	Bucharest	Brown Boveri	P	1948	1x10	Natural Gas	0	600	12		0	2	21.4	2	4,000							3,000
21	Sweden	Västervik	Ljungstrom	P	1959	1x40	Liquid	0	700	13	1	0	1	26.9	2	(3,750 (3,100	..	2	3,750 3,100	..	..	..	3,000
22		Varberg	Ljungstrom	P	1956	1x10	"	0	730	9.8	0	0	1	25.2	1	(6,350 (5,200	..	1	6,350 5,250	5	15,000	6.3	3,000
23		Ottorbäcken	Brown Boveri	P	1957	1x25	"	0	650	16	2	0	2	24.0	2	4,750	..	2	4,750	..	37,500	10	3,000
24		Oxelösund	Brown Boveri	P	1962	1x25	"	0	650	16	2	0	2	24.0	2	4,750	..	2	4,750	..	37,500	..	3,000
25	Switzerland	Neuchatel	Brown Boveri	P	1939	1x4	Liquid	0	550	4	0	0	1	16.9	1	3,000	88	1	3,000	84.6	..	..	3,000
26		Bosnau	Brown Boveri	BP	1948	1x13	"	0	650	8.8	1	80	2	30.0	2	4,750	..	2	3,000	..	16,000	8	3,000
27		"	" "	BP	1949	1x27	"	0	650	8.1	2	80	2	30.0	2	3,000	..	2	3,000	..	33,000	8	3,000
28		Rheinfelden	Sulzer	BP	1959	2x10	"	0	620	4.3	0	70/00	1	26.5	1	..	90	1	..	88	15,000	8	3,000
29	USSR	Shatsk	Loningrad Metal Works	B	1958/1959	2x12	Underground coal gas	0	650	12	1	80	2	27.0	2	..	88	..	..	89	..	..	3,000
30		"	" " "	EH	1962	1x25	Natural gas	0	700	10	1	80	1	28.4		3,000		1	..	..	30,000	..	3,000
31		"	" " "	EH		1x100	Gas, liquid fuel	0	750	20	3	80	2	36.0	2	..	89	3	..	90	..	..	3,000
32		"	" " "	BP		1x100	" " "	0	750		1	0	1	27.0	2	..	89	2	..	90	..	..	3,000
33		"	" " "	"	1961	1x9	Natural gas	0	750	4.5	0	70	1	25.0	1	4,100	..	1	5,000	..	..	..	..
34		Kharkov	Kharkov Turbine Works	EH	1961	1x50	" "	0	800/770	18	2	75	2	33.5	2	3,600/3,000	..	2	3,600/3,000	..	..	..	3,000
35		Kashira	Escher-Wyss	EH	1960	1x10	Pulverised coal	C	677	4.4	1	91	1	28.5	1	6,634	89	2	6,634	85	15,000	..	3,000
36	Federal Republic of Germany	Bremen-Vahr	Brown Boveri	EH	1960/1961	2x25	Fuel oil	0	630	16	1	75	2	25.2	2	4,500/3,000	..	2	4,500/3,000	..	33,000	10.5	3,000
37		München-Sendling	Siemens-Schuckert	EH	1961	1x22	Gas, fuel oil	0	720	6		80	2	28.0	1	3,000	..	1	3,000	..	..	10.5	3,000
38		Oberhausen	Escher-Wyss, GEH	B,EH	1960	1x12.5	Pulverised coal	C	710	8	2	92	1	29.5	1	6,640	..	2	6,640	..	16,000	..	3,000
39		Rheinhausen	Brown Boveri	B	1959/1960	2x15	Blast furnace gas	0	750	5.1	0	75	1	26.3	1	3,000	..	1	3,000	..	20,000	5.2	3,000
..																							
40		Coburg	Escher-Wyss, GEH	EH	1959	1x6.6	Pulverised coal	C	680	4.0	2		1	29.0	1	..	..	..	..	..	..	..	3,000
41		Duisburg	Brown Boveri	BP	1957	1x5.8	Blast furnace gas	0	750	5.1	0	75	1	27.0	1	4,750	..	1	5,250	..	4,600	5.2	3,000
42		Ravensburg	Escher-Wyss, GEH	EH	1956	1x2.3	Pulverised coal	C	660	4.0	2+1	85	1	26.0	1	12,760	..	2	12,750	..	..		3,000

TABLE I (continued)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
43	Canada	Port Mann	Brown Boveri	PC	1959	4x25	Natural gas, crude oil	C	650	16	1	0	2	24.0	2	4,500	..	2	4,500	..	30,000	13.8	3,600
44		Bare Point (Vancouver)	General Electric	PS	1959/1960	(2x20 (2x18	Fuel oil "	O C	737 737	6.4 6.4	0 0	0 ..	1 1	21.1 28.6	1 1	3,600 3,600	.. ..	1 1	3,600 3,600	.. ..	25,000 25,000	13.8 13.8	3,600 3,600
45		Edmonton (Alberta)	Brown Boveri	PS	1958/1959	2x25	Natural gas	O	650	16	1	0	2	24.0	2	..	..	2	4,750	..	..	..	..
46		Kindersley (Regina)	" "	PC	1958	2x10	" "	O	650	4.6	0	0	1	19.0	..	..	..	..	..	..	..	..	..
47	United States of America	Rutland	General Electric	BP	1952	3x5	Fuel oil	C	816	9	1	0	1	26.4	1	..	..	1	8,300	..	..	..	3,600
48		Orlando	" "	P	1958/..	2x16.2	" "	O	737	6	0	0	1	20.6	1	..	..	1	..	..	..	..	..
49		Philadelphia	Westinghouse	P	1962	1x22	Natural gas diesel oil	O	788	..	..	..	..	..	..	..	..	..	..	..	..	..	..
50	Peru	Lima	Brown Boveri	B	1949	1x10	Fuel oil	O	600	8	..	80	2	28.2	2	..	..	1	6,900	..	..	..	3,600
51	Venezuela		General Electric	PS	1957	1x16.5	Natural gas crude oil	O	788	6	0	0	1	20.6	1	..	..	1	3,600	..	..	..	3,600

Notes: a) B - base load
P - peak load
S - stand-by capacity

EH - electricity and heat
.. - no information available

b) O - open cycle
C - closed cycle
FP - with three-piston generators

Table 2

GAS TURBINE PLANTS FOR POWER ALREADY USED IN LESS DEVELOPED COUNTRIES

No	Country	Location of the plant	Manufacturer	Commissioning time	Capacity kW	Cycle	Initial temperature	Compression Ratio	Regenerating efficiency %	Fuel used	Thermal efficiency %	Purpose of the plant
1	Algeria	Hassi Messaoud	Fiat	1962	2 x 6400	0	788	6	. .	gas, liquid	. .	Production of electricity
2	"	Sahara	"		2 x 6400	0	788	6	. .	" "		"
3	"	Haoudel Hamra	"	1960	1 x 6400	0	788	6	. .	" "		"
4	"	Santa Cruz	Brown Boveri	1957	2 x 12000	0	650	4	0	Bunker oil	19,5	"
5	"	Haoudel Hamra	"	1960	2 x 4700	0	650	.	. .	gas	. .	"
6	"	Bône	Oerlikon	1952	1 x 760	0	600	3,75	0	Bunker oil	15,9	Electricity and steam
7	Argentina	Blanco Encalada	Fiat	1961/1962	2 x 6400	0	788	6	. .	liquid	. .	Production of electricity
8	"	Mobile plant	"	1961/1962	2 x 6400	0	788	6	. .	gas, liquid	. .	"
9	"	Sinco saltos	"	1961	1 x 6400	0	788	6	. .	gas, liquid	. .	"
10	"	Barker	"	1961	2 x 5850	0	788	4	. .	gas, liquid	. .	"
11	"	Lujande	"	1961	2 x 6400	0	788	6	. .	gas, liquid	. .	"
12	"	Pico Truncado	"	1961	2 x 6400	0	788	6	. .	gas, liquid	. .	"
13	"	Atnor	General Electric	1961	1 x 5500	0	. .	. .	. .	. .	. .	"
14	"	Olavarria	Zulzer	1962	1 x 6100	0	. .	. .	. .	liquid, gas	. .	"
15	Bahrain	Manama	Brown Boveri	1958/1961	4 x 6000	0	650	4,6	0	gas	19,0	Oil field
16	Brazil	Nova cap	General Electric	1961	2 x 5300	0	. .	. .	. .	. .	. .	Production of electricity
17	"	. .	Westing-house		4 x 6400	0	788	6	0	. .	. .	"
18	Ecuador	Ankon	Ruston Hornsby	1961	1 x 930	0	727	4	0	gas	15,9	"
19	Egypt	Tura	SEME (France)	1957	1 x 3750	F.P	450	4	0	Bunker oil	34,0	"
20	"	Alexandria	Brown Boveri	1949	1 x 1200	0	593	3	. .	"	21,6	"
21	India	. .	Westing-house	Placed order	3 x 23000	0	788	. .	. .	. .		"
22	Iran	Tembi	Brown Boveri	1955/1956	2 x 4000	0	593	. .	0	gas	16,4	"
23	Lebanon	Beirut	Westing-house	1955	1 x 5000	0	732	5,8	0	kerosine Bunker oil	19,0	"
24	Libya	. .	Ruston Hornsby	1961	3 x 900	0	727	4	. .	. .	. .	"
25	Mexico	Mexico City	Brown Boveri	1957/1958	3 x 6200	0	650	4,7	0	Bunker oil	19,1	Mobile plant
26	"	. .	Westing-house	. .	5 x 6400	0	788	6	. .	. .	. .	Production of electricity
27	"	. .	"	. .	1 x 14000	0	788	6	0	. .	. .	"

Table 2

GAS TURBINE PLANTS FOR POWER ALREADY USED IN LESS DEVELOPED COUNTRIES

NO	Country	Location of the plant	Manufacturer	Commissioning time	Capacity kW	Cycle	Initial Temperature	Compression Ratio	Regenerat. efficiency %	Fuel used	Thermal efficiency %	Purpose of the plant
28	Pakistan	Mulfan	Brown Boveri	1960	1 x 5700	0	. .	..	. .	gas, Diesel oil	. .	Production of electricity
29	"	Huderabad	"	1961	1 x 5700	0	. .	. .	. .	"		"
30	Peru	Santa Rosa	"	1949	1 x 10000	0	593	8	80	Bunker oil	28,2	"
31	"	Chimbot Lima	"	1949	1 x 4000	0	593	4,6	0	"	18,3	"
32	"	Santa Rosa, Lima	"	1961	2 x 10000	0	650	. .	0	"		"
33	Saudi Arabia	Drahran	"	1954/ 1956	3 x 5000	0	650	4,6	0	Gas, bunker oil	17,0	"
34	"	Jeddah	"	1955/ 1956	3 x 6000	0	650	4,6	0	Bunker oil	19,0	"
35	"	Riyadh	"	1958/ 1960	4 x 6000	0	650	4,6	0	Bunker oil	19,0	"
36	Venezuela	Pertigalete	"	1949	2 x 1650	0	593	3,0	0	Bunker oil	20,7	"
37	"	"	"	1953/ 1955	2 x 5000	0	650	4,0	75	Gas, Bunker oil	24,0	"
38	"	Pertigalete	"	1960	1 x 5900	0	650	4		"	. .	"
39	"	ElConvento	"	1958	1 x 20000	0	650	16	0	gas	24,0	"
40	"	. .	Westing-house	1954/ 1959	5 x 5000	0	732	5,8	0	"	18,6	"
41	"	. .	General Electric	1957	1 x 16500	0	788	16	0	gas, kerosine	20,6	"
42	Nigeria	. .	Clark Bros.	1962	2 x 6350	0	732	. .	0	. .	. .	"

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